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(Research Article)

A TRIZ approach to motorcycle passenger comfort in developing an ergonomic Backrest

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Abstract

Motorcycle ride-hailing services are increasingly popular among women in Indonesia, but concerns about comfort and safety, particularly regarding physical contact with drivers, remain significant. This study explores the application of the TRIZ method to design an ergonomic backrest specifically for female passengers, addressing these concerns through innovative solutions. The backrest design incorporates anthropometric data of Indonesian women to ensure compatibility with user body dimensions. Key dimensions include a height of 64.95 cm, shoulder width of 41.06 cm, and headrest width of 20 cm, with added allowances of 2–5 cm for height and 2–4 cm for width. Using aluminum alloy for the frame, polyurethane foam with synthetic leather for padding, and high-carbon steel for support legs, the backrest is equipped with adjustable height, quick-lock mechanisms, and anti-slip features. Testing demonstrated that the design effectively improves passenger comfort and creates a safe distance between passengers and drivers, particularly during long journeys. Despite its success, this study is limited by the exclusion of cost considerations and testing confined to specific conditions. Future research is recommended to explore cost analysis, broader field trials, additional features such as foldable designs, and material durability to enhance the backrest's practicality and inclusivity.

Keywords: Ergonomics; TRIZ; Backrest Design; Product Design; Motorcycle Ride-Hailing Services; Anthropometry

1. Introduction

In recent years, motorcycle ride-hailing have become a popular and practical transportation solution in major Indonesian cities. This service offers convenience and efficiency for many people, especially amidst traffic congestion. However, there are concerns regarding safety and comfort, particularly for female passengers. According to Djunaidi et al. (2023), with the increasing number of online motorcycle taxi users in Indonesia, especially women, there is a growing need to ensure their comfort and safety during trips [1]. Data from the National Transportation Safety Committee (KNKT), cited in Tempo, reveals that road accidents dominate as the leading cause of casualties compared to other modes such as railways, maritime, and aviation. Between 2020 and 2024, there were 282 fatalities and 678 injuries reported on roads. Maritime accidents followed, with 179 fatalities and 95 injuries [2].

Research shows that many women feel uncomfortable with physical contact while using online motorcycle taxis, mainly due to cultural and privacy concerns [3]. Passenger-friendly vehicle designs and safety regulations, such as emergency buttons and location-sharing features, can enhance comfort; however, the perception of risk remains high [3,4]. Improperly designed speed bumps can cause discomfort and increase accident risks, especially if they are too high or steep [5]. The Indonesian National Standard (SNI) 1732:2008 regulates speed bump specifications to ensure comfort, recommending a width of 30-90 cm, a maximum height of 12 cm, and a minimum distance of 10 meters between speed

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bumps, as shown in Figure 1. Speed bumps are advised for residential areas rather than main roads, where they may disrupt traffic flow.

Figure 1 Speed Bumps Indonesian National Standard (SNI) 1732:2008

Anthropometry studies the measurements of the human body and its interaction with the environment. In the context of designing Motorcycle ride-hailing, understanding the anthropometry of passengers, particularly women, is essential to enhance comfort and reduce the risk of injury. [6] suggest that the dimensions of the seat, backrest, and handles should be adjusted based on anthropometric data such as height and arm length. Designs that incorporate these considerations can improve comfort, especially for passengers who are reluctant to have physical contact with the driver. [7] highlight that a stable backrest can help motorcycle ride-hailing passengers maintain balance without needing to hold onto the driver. Anthropometry-based designs tailored for women provide greater comfort and safety, particularly on uneven roads, thereby improving the quality of motorcycle ride-hailing services. This study reveals that women seek safer solutions without physical contact with the driver, leading to the idea of developing a specialized backrest to enhance their comfort during rides. This design approach is particularly relevant in addressing challenges posed by non-standard road conditions, such as excessively high or rough speed bumps, which can cause excessive jolts and increase the risk of injury for passengers without a stable grip. Thus, this research aims to design a tool that reduces discomfort for female motorcycle ride-hailing passengers by considering the necessary safety and comfort aspects. The expected outcome is a design that enhances the quality of online motorcycle taxi services while creating a safer and more comfortable experience for users.

2. Material and methods

2.1. Anthropometry

Anthropometry is the science of studying human body dimensions and their application in product design, ensuring that products fit the shape, size, and needs of users. In this study, anthropometric data of female users is utilized to develop a comfortable and safe backrest for female online motorcycle taxi passengers. The goal is to create a design that is not only ergonomic but also accommodates variations in women's body sizes to minimize physical contact with the driver. Steps for Using Anthropometry in Backrest Design [11]:

- Anthropometric Data Collection Gather key body dimension data from users, such as back height, shoulder width, and torso length. This data ensures that the backrest is designed to match users' body sizes, providing comfort and stability during use.
- Determination of Average Size and Percentiles Use anthropometric data to determine average sizes, typically within the 5th to 95th percentiles. This approach ensures that the backrest design accommodates the needs of most users with proportionate body size variations.
- Prototype Design Based on the analysis of a body dimension, the backrest is designed to provide support and comfort without causing strain on the back. The height and width of the backrest are adjusted to promote proper posture.
- Comfort Testing and Evaluation The prototype is tested by users with varying body sizes to ensure the design supports natural posture and is comfortable to use. The results of these tests are used to make final adjustments to the design to meet user comfort needs.

2.2. TRIZ (Theory of Inventive Problem Solving)

This study employs the TRIZ method (Theory of Inventive Problem Solving), which has evolved into a systematic framework for innovative problem-solving. By applying TRIZ principles, this research identifies and resolves contradictions in the backrest design to meet the needs of female customers who prefer to avoid physical contact with online motorcycle taxi drivers. The TRIZ method facilitates more efficient and innovative design by reducing the product development time typically required for trial and error [8]. The steps in applying the TRIZ method are as follows:

2.2.1. Problem Identification

Define functional requirements, such as avoiding physical contact while maintaining comfort.

2.2.2. Contradiction Analysis

Identify conflicts, such as ensuring comfort while avoiding physical contact, using the TRIZ contradiction matrix [9].

2.2.3. Application of Innovation

Principles Apply principles such as "Separation in Space" to design a flexible backrest that maintains a safe distance.

2.2.4. Design Development and Evaluation

Develop and evaluate design concepts to ensure user comfort and requirements are met.

2.2.5. Testing and Refinement

Test prototypes with users, then refine the design based on test results to achieve the desired comfort and distancing [10].

2.3. Dimensional Factor

In designing an ergonomic backrest for female passengers, several key dimensional factors must be considered to ensure the product provides comfort, safety, and supports good posture during use. Below are the essential dimensional factors for this design:

- Comfort factor refers to the extent to which the backrest can support the body without causing discomfort or fatigue. Dimensions influencing comfort include:
    - Backrest height: Should be high enough to support the upper back [11].
    - Backrest width: Must not be too narrow or too wide, ensuring proper support for the shoulders and mid-back [11].
    - Backrest position: Designed to follow the natural curve of the back so users can sit comfortably without feeling overly pushed forward or reclined [12].
- Safety factor ensures the user's stable position during the ride. Dimensions supporting safety include:
    - Seat height and elbow height: Adjusted to match anthropometric dimensions for user stability during movement [13].
    - Backrest thickness and stability: Ensures the backrest is strong enough to support the user on uneven roads [13].
- Posture Support factor because the backrest should help users maintain good posture, preventing muscle strain, especially during long rides. Dimensions supporting posture include:
    - Shoulder height in a seated position: Ensures the backrest aligns with the user's shoulders, keeping the back upright [13].
    - Knee length and upper shoulder width: Helps users sit comfortably without forcing a position that could strain the neck or back muscles [11].
- Balance and Stability factor is crucial to prevent shifting or imbalance during the ride. Dimensions influencing balance include:
    - Seat base width: Increases stability and ensures the backrest does not easily shift [13].
    - Ergonomic design based on body weight distribution: Ensures the backrest remains stable without tipping forward or backward when the user sits or leans back [12].
- Flexibility and Adjustability factor to accommodate various body sizes, such as:
    - Adjustable height: Aligns the backrest with the user's sitting height [13].
    - Inclination angle: Allows the backrest to follow the body's position, enhancing comfort and stability [12].

These factors serve as guidelines to ensure the backrest design delivers a more comfortable, safe, and posture-supportive riding experience for female users of online motorcycle taxi services.

2.4. Data Collection

The collection of anthropometric data plays a crucial role in creating ergonomic products tailored to specific users. In this project, the focus is on gathering anthropometric data for women aged 16 to 34 years to ensure that the resulting design provides optimal comfort and safety for users. To streamline the process, secondary data will be gathered from the Indonesian Ergonomic Association website. The selection of secondary data is considered strategic, as it saves time while ensuring accuracy through already verified information. During the data collection process, several key body dimensions will be used as primary parameters, including: sitting height, shoulder height when seated, knee length, upper shoulder width, and elbow height in a seated position. Utilizing this data ensures that the product design is aligned with the physical needs of the target female users, providing a high level of comfort and safety.

This method is divided into three main stages: identifying the problem using the Innovation Situation Questionnaire (ISQ) to understand the functional requirements of the design, which is to create a backrest that allows comfort without physical contact between the driver and the passenger; formulating the problem by identifying key contradictions, such as maintaining comfort while avoiding physical contact; and the problem-solving phase, where TRIZ innovation principles are applied to design a flexible and ergonomic backrest that ensures optimal comfort for female online motorcycle taxi passengers.

2.5. Data Processing Techniques

To ensure that the resulting backrest design meets ergonomic standards and provides optimal comfort for users, precise data analysis techniques are essential. These techniques not only help in understanding the anthropometric characteristics of users but also play a significant role in identifying design challenges and testing innovative solutions. Each stage of analysis is meticulously planned to filter data comprehensively, ensuring that the final output aligns with the ergonomic needs of passengers. The first technique involves descriptive statistical analysis of anthropometric data. This approach identifies data distribution, such as sitting height, knee length, shoulder width, and elbow height. It includes calculations of averages, medians, standard deviations, and percentiles (e.g., 5th to 95th percentiles).

These results serve as the foundation for ensuring the backrest design accommodates the body size variations of the majority of female users safely and comfortably. Next, the TRIZ contradiction matrix analysis is employed to address design issues related to comfort and safety. For instance, a contradiction between the need to avoid physical contact and maintaining passenger stability can be resolved by selecting appropriate TRIZ principles. This matrix serves as a critical tool in identifying innovative solutions that remain consistent with ergonomic principles. The subsequent stage involves prototype evaluation through user trials. Once the backrest design is developed, the prototype is directly tested by a user group with varying body sizes. Data collected from these trials are analyzed to assess the comfort, stability, and usability of the designed backrest. In the final stage, both quantitative and qualitative analyses of user feedback are conducted. Quantitative data, such as comfort scores, along with qualitative data from interviews or written feedback, are utilized to refine the final design. This analysis ensures that the resulting backrest fully addresses user needs and resolves any issues or complaints identified during the initial identification phase.

3. Results and discussion

The determination of these dimensions aims to ensure comfort, safety, and the suitability of the design to meet user needs. The following table presents relevant body dimensions, their respective functions in the context of backrest design, and the requirements they must fulfill. The anthropometric data is sourced from the database provided by antropometriindonesia.org [14], focusing on the female population, which is the target group for this design.

The data processing in this research involves three main stages. First, the data is analyzed using the TRIZ (Theory of Inventive Problem Solving) method, which aims to identify innovative solutions to design challenges. Second, percentile calculations are conducted to determine the relevant body dimensions of users, ensuring the product design accommodates the majority of the target population. Lastly, the results from these calculations are used to determine product dimensions, ensuring alignment with ergonomic principles and user needs.

Table 1 Recapitulation of Anthropometric Data

No	Dimension Code	Body Dimension	Function	Requirement
1	D8	Sitting Height	Determines the height of the backrest	Ensures comfort and proper back support
2	D19	Hip Width	Adjusts backrest width to fit the user	Prevents discomfort caused by limited space
3	D10	Shoulder Height (Sitting)	Maximum position for backrest height	Provides optimal support for the back
4	D27	Head Width	Width of the headrest area	Ensures maximum support for the head area

Source: Adapted from Indonesian Anthropometric Database

3.1. TRIZ

The following is the procedure for using the TRIZ method in this research to identify innovative solutions for the design of an online ride-hailing passenger backrest.

3.1.1. Identifying Technical Contradictions

Technical issues are identified based on conflicting features in the backrest design. In this study, technical contradictions are derived from opposing technical responses, as shown below:

Table 2 Technical Responses 1

No.	Technical Response 1
1	Lightweight backrest for easy installation
2	Flexible backrest to follow movements

This table presents two key technical responses in designing the backrest. The first is making it lightweight to ensure easy installation and handling, which improves usability but may compromise structural strength. The second is designing a flexible backrest that follows the user's movement for greater comfort, but this could lead to stability issues, requiring additional design considerations.

Table 3 Technical Responses 2

No.	Technical Response 2
1	Sturdy backrest for full support
2	Fixed backrest to maintain body balance

This table discusses the need for a sturdy backrest that provides full support and enhances user safety. However, a strong and rigid design may add excessive weight, reducing portability. Additionally, a fixed backrest helps maintain body balance during rides but limits user flexibility. These conflicting needs require a balanced approach in material selection and structural design.

3.1.2. Identifying Features and Issues in Technical Responses

The following outlines the identification of features and problems arising from the identified technical contradictions. This process utilizes the 39 Worsening Features guideline as found in this link [15] to systematically address design issues:

Lightweight backrest for easy installation vs. sturdy backrest for full support. This issue falls under the category of "Ease of Use" and can be resolved through the Improvement of Structural Stability (Feature 11) approach.

Table 4 Contradictions Between Technical Responses 1

Specific Problem	Useful Feature	Harmful Feature	TRIZ Principle
Backrest Weight	Lightweight backrest	Reduces structural strengths	1 (Segmentation), 15 (Dynamics)
Backrest Structure	Provides full support	Increases weight or mass	10 (Preliminary Action), 35 (Physical Parameters)
General Problem			
Shape (12)	Increase design efficiency to be lightweight and ergonomic		Reduce structural durability due to material reduction
Ease of Operation	Ease of installation and removal of the backrest		Reduces design stability due to safety compromise

This table examines the trade-off between a lightweight backrest for convenience and the necessity for structural strength. The TRIZ method suggests using segmentation (breaking down the structure into smaller, manageable parts) and dynamic design (allowing adjustments based on user needs) to achieve both lightweight properties and durability without sacrificing stability.

Flexible backrest following movement vs. fixed backrest to maintain body balance.

This contradiction falls under "Adaptability and Stability" and can be resolved using the Modular or Flexible Elements (Feature 10) principle.

Table 5 Contradictions Between Technical Responses 2

Specific Problem	Useful Feature	Harmful Feature TRIZ Principle
Backrest Flexibility	Allows free movement	Reduces structural strength
Backrest Stability	Maintains body balance	Increases weight or mass
General Problem		
Volume (7), Weight of moving object (1)	Ease of design adjustment to user needs	Potential decrease in user comfort

This table highlights the contradiction between a flexible backrest that enhances comfort and a stable backrest that ensures safety. Solutions based on the TRIZ method include using modular components that allow for controlled movement while maintaining overall structural integrity. Selecting lightweight but high-strength materials can also provide both flexibility and stability.

Backrest size adjusted to user vs mass production with standard sizes Table 6. Contradictions Between Technical Responses 3

Table 6 Contradictions Between Technical Responses 3

Specific Problem	Useful Feature	Harmful Feature TRIZ Principle
Size adjustment	Provides comfort for users	Requires higher production costs
Standard production	Reduces production costs	Not suitable for all users
General Problem		

Shape (12),	Enhances design efficiency to be lightweight and ergonomic	Reduces structural durability due to material reduction
Comport (13)	Ensures the backrest provides ergonomic comfort	Reduces design stability due to compromises on safety
Adaptability (35)	Design flexibility for various user sizes and body shapes	Reduces design stability due to excessive flexibility
Cost (27)	Risk of increased costs that must be minimized to maintain economic efficiency	Reduces material quality

This table addresses the conflict between designing a backrest that adjusts to different user sizes for optimal comfort versus the cost-effectiveness of mass production with standardized sizes. To balance these factors, TRIZ principles like parameter modification and adaptability are applied, allowing for an efficient design that accommodates a wide range of users without significantly increasing production costs.

3.1.3. Contradiction Matrix

The contradiction matrix resulting from the technical response contradictions was generated using the TRIZ 40 Contradiction Matrix tool available on https://www.triz40.com. The results are as follows:

Table 7 Contradictions Between Technical Responses 1

Feature to Improve	**Feature to Preserve**
Shape (12)	Ease of operation (33)
Problem Solving	
Inventive Principle	Description
Colour changes (32)	Altering the colour of an object or its external environment.
Dynamics (15)	Designing the characteristics of an object, external environment, or process to optimally change.
Copying (26)	Using simpler and more affordable copies.

This table presents the TRIZ-based solutions for resolving conflicts between shape and ease of use. Recommended approaches include using color changes to indicate adjustment settings, designing dynamic components for better flexibility, and duplicating key ergonomic elements from proven designs to enhance comfort and usability.

Table 8 Contradictions Between Technical Responses 2

Feature to Improve	**Feature to Preserve**
Volume of moving object (7)	Weight of moving object (1)
Problem Solving	
Inventive Principle	Description
Taking out (32)	Separating the interfering part of an object or emphasizing only a specific part.
Copying (26	Using simpler and more affordable copies.
Copying (26)	Utilizing parts of an object made of gas or liquid instead of solid parts (e.g., inflatable, liquid-filled, air cushion, hydrostatic, hydro-reactive).
Composite materials (40)	Switching from uniform materials to composite (diverse) materials.

This table explores how to manage the trade-off between volume and weight. The proposed TRIZ solutions involve removing unnecessary parts to reduce mass, using composite materials to maintain strength while lowering weight, and integrating inflatable or adaptive structures to enhance flexibility without adding bulk.

Table 9 Contradictions Between Technical Responses 3 a

Feature to Improve	**Feature to Preserve**
Shape (12)	Cost (23)
Problem Solving	
Inventive Principle	Description
Composite materials (40)	Switching from uniform materials to composite (diverse) materials.
Partial or excessive actions (16)	If achieving 100% of the ideal shape or position is challenging with one method, use an approach that is "slightly more" or "slightly less" than the method.
Preliminary action (10)	Make necessary changes to the product beforehand to simplify subsequent processes.

This table focuses on resolving conflicts between shape and cost. Suggested solutions include switching to composite materials that offer a balance between affordability and durability, implementing partial or excessive actions (designing slightly larger or smaller elements for efficiency), and using pre-adjustable configurations to streamline the manufacturing process.

Table 10 Contradictions Between Technical Responses 3 b

Feature to Improve	**Feature to Preserve**
Comfort (13)	Adaptability (35)
Problem Solving	
Inventive Principle	Description
Parameter changes (35)	Modify the physical conditions of the product to simplify production or enhance comfort.
Discarding and recovering (34)	Parts that have fulfilled their function can be removed or modified during use.
Taking out (2)	Separate the interfering part or property from an object, or highlight the only necessary part or property.

This table examines the contradiction between comfort and adaptability. TRIZ-based solutions involve modifying design parameters to make the backrest more flexible, incorporating a folding system for easy storage, and using thin, flexible layers to enhance comfort while maintaining structural integrity. Additional strategies include developing modular components that can be adjusted or removed to suit different user preferences.

3.1.4. Alternative Solutions

Based on the results of the previous contradiction matrix, the following are alternative solutions that can be applied to design a motorcycle seat backrest in accordance with the TRIZ problem-solving principles obtained.

Table 11 Solution 1

TRIZ Problem Solving	**Solution**
Colour changes (32)	Use materials or paint that are highly visible at night
Dynamics (15)	Design the motorcycle seat backrest to be adjustable according to the rider's posture.

Copying (26)	Develop a backrest prototype based on anthropometric data to ensure ergonomic suitability

Table 12 Solution 2

TRIZ Problem Solving	Solution
Taking out (32)	Remove unnecessary parts of the backrest, such as decorative elements, to reduce overall weight and focus ergonomics on user comfort.
Copying (26)	Develop a backrest prototype by mimicking the anatomy of the human spine or proven ergonomic chair designs for optimal comfort.
Pneumatics and hydraulics (29)	Add a pressure adjustment mechanism using air or liquid-based materials, allowing the backrest firmness to be adjusted according to user needs.
Composite materials (40)	Use lightweight yet strong composite materials, such as carbon fibre and memory foam blend, to create an ergonomic and durable backrest.

Table 13 Solution 3a

TRIZ Problem Solving	Solution
Composite materials (40)	Use lightweight yet strong composite materials, such as a blend of carbon fibre and memory foam, to create an ergonomic and durable backrest.
Partial or excessive actions (16)	Provide options for excessive adjustment of the backrest angle or height to accommodate various user preferences, even if only some features are frequently used.
Preliminary action (10)	Install a mechanism that allows users to adjust the backrest before starting their journey, ensuring the backrest position is optimal from the beginning.

Table 14 Solution 3b

TRIZ Problem Solving	Solution
Parameter changes (35)	Modify the design parameters, such as making the backrest more flexible or incorporating a folding system for easier storage or use on different types of motorcycles.
Flexible shells and thin films (30)	Use thin, flexible layers over the main material to enhance comfort without significantly adding to the thickness.
Discarding and recovering (34)	Develop a backrest with removable and replaceable parts, making it easy to repair or upgrade without replacing the entire unit.
Taking out (2)	Remove unnecessary parts of the backrest, such as decorative elements, to reduce overall weight and focus ergonomics on user comfort.

3.1.5. Selecting the Best Solution

Based on the various TRIZ solutions identified, the final stage involves selecting the best solution that aligns with the design requirements for the motorcycle seat backrest. The chosen solution should effectively address the identified contradictions, improve ergonomics, maintain production efficiency, and meet user needs for comfort and adaptability. This process ensures that the product design is both functional and practical, leading to an optimized and user-friendly backrest design.

Table 15 Selecting the Best Solution

No	Principle TRIZ	Alternative Solution	Relevance to Motorcycle Backrest
1	Composite Materials (Principle 40)	Using lightweight yet strong composite materials, such as a mixture of carbon fibre and memory foam.	Increase user comfort without adding weight to the motorcycle. Lightweight material reduces fatigue during long journeys. Durable and aesthetic.
2	Dynamics (Principle 15)	Design components that can move or change position as needed.	The backrest can be adjusted in angle or height to support various user postures. Provides flexibility for better comfort. Accommodates various user preferences with a simple mechanism.
3	Copying (Principle 26)	Mimicking human anatomical design elements or proven ergonomic devices.	The backrest follows the shape of the user's back for optimal comfort. Minimizes direct contact between the user and the driver. Provides ergonomic support that supports a safer and more comfortable journey.
4	Flexible Shells and Thin Films (Principle 30)	Using lightweight, flexible and durable materials to increase comfort.	Flexible material follows the user's body shape for maximum comfort. Does not add significantly to the weight of the motorcycle. Can be used as an aesthetic and durable backrest cover, adding functional and visual value.

3.2. Determining Percentiles and Product Sizes

The determination of percentiles and product dimensions is a critical step in ergonomic design to ensure that products meet the needs of diverse users. Anthropometric data serve as a reference to keep the design comfortable, safe, and efficient while considering variations in users' physical characteristics.

3.2.1. Backrest Height

The motor seat backrest height is designed based on shoulder height in the sitting position using the 95th percentile anthropometric data, which is 64.95 cm. An additional tolerance (allowance) is applied to ensure the backrest accommodates users with taller body postures. Reasons for Choosing the 95th Percentile:

- Accommodating Taller Users

Designing the backrest using the 95th percentile ensures it is tall enough to support users with greater sitting shoulder height. A lower backrest could lead to inadequate support, resulting in fatigue or discomfort.

- No Negative Impact on Shorter Users

Users with shorter shoulder height will still feel comfortable since a higher backrest does not negatively affect their experience. Instead, it provides additional support beyond their minimum needs.

3.2.2. Backrest Width

The backrest width is designed based on shoulder breadth in the sitting position at the 95th percentile, which is 41.06 cm. An additional tolerance (allowance) is also applied to enhance flexibility and comfort for users. Reasons for Choosing the 95th Percentile:

- Accommodating the Majority of Users

Using the 95th percentile ensures that the backrest can accommodate most users, including women with broader shoulders. This is essential for optimal comfort and support during use.

- Preventing Discomfort for Users with Broad Shoulders

A backrest design based on lower percentiles (e.g., 50th or 5th) would result in a backrest that is too narrow, potentially causing pressure on the shoulder area and increasing discomfort.

3.2.3. Headrest Cushion Width

The width of the headrest cushion is designed based on head width in the sitting position using the 95th percentile anthropometric data. Reasons for Choosing the 95th Percentile:

- Accommodating Users with Larger Head Sizes

Using the 95th percentile ensures that the cushion can provide optimal support for users with larger head sizes. A narrower cushion could result in discomfort due to insufficient support.

- Comfort for Users with Smaller Head Sizes

The headrest cushion width at the 95th percentile remains comfortable for users with smaller head sizes because the design considers load distribution and an ergonomic head position.

3.2.4. Allowance in Backrest Design

To ensure an ergonomic and flexible design, additional tolerance is applied to the backrest dimensions as follows:

- Backrest Height

An allowance of 2–5 cm is added to accommodate users with taller body postures.

- Backrest Width

An allowance of 2–4 cm is added to provide extra flexible space for users with broader shoulders, without reducing comfort for users with narrower shoulders.

3.3. Product Design

The ergonomic backrest product is specifically designed to meet the needs of female passengers using Motorcycle ride-hailing services. The design process utilizes SOLIDWORKS software.

3.3.1. Product Specifications

The following is the result of the passenger backrest product design along with its specifications, as shown in Figure 2 and Figure 3.

Figure 2 Front View Product Design Results

From the front view, the backrest consists of two main parts: the upper headrest and the adjustable lumbar support. These components are designed to follow the human body anatomy, providing optimal support for the upper back and waist areas. The dimensions of the backrest are adjusted according to the average female body size based on anthropometric data.

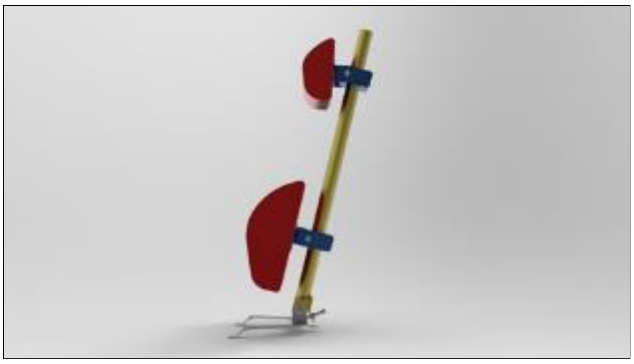

Figure 3 Product Design Results Side View

The side view shows the backrest structure equipped with an adjustable tilt angle, allowing comfort for users with different body postures. The mounting system uses corrosion-resistant aluminum alloy clamps to ensure strength and stability when used on various road conditions.

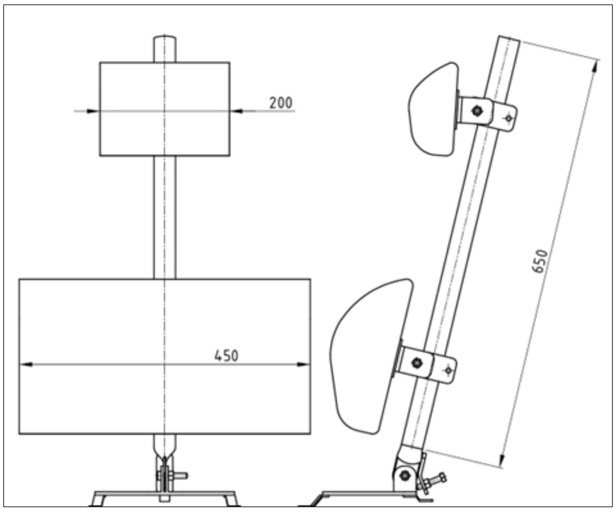

Figure 4 Product Design Size Details

Figure 4 created using AUTOCAD, shows the detailed dimensions of each backrest component, including length, width, and spacing between elements. The total dimensions of the backrest are 650 mm in length, 200 mm in head width, and 450 mm in back width, with supports that can be adjusted to fit various types of online motorcycle taxis. This size adjustment enables flexible use without compromising stability.

3.3.2. Product Comfort and Safety Aspects

Comfort and safety are the primary factors in the backrest design. Online motorcycle taxi passengers, who often face uneven road conditions and long trips, require a backrest that can provide proper body support. Therefore, this design prioritizes cushion materials that are soft yet able to maintain backrest stability. In addition, safety aspects include selecting strong and durable materials, as well as secure locking mechanisms to ensure the backrest remains stable during the journey. The comfort and safety aspects of the passenger backrest product are presented in Table 16.

Table 16 Product Comfort and Safety Aspects

Component	Recommended Material	Reason for Material Selection	Safety Aspect	Comfort Aspect
Backrest Cushion	*Polyurethane Foam* with Synthetic Leather Cover	Absorbs pressure and provides comfort. Water-resistant and easy to clean. Durable and tear-resistant.	Absorbs shocks, protects the spine from injuries on bumpy roads. Anti-slip layer prevents slipping.	Soft cushion provides comfort even on long journeys. Synthetic leather cover remains cool on contact.
Main Frame	*Aluminium Alloy*	Lighter and corrosion-resistant. Suitable for supporting backrest stability.	Prevents frame from breaking or bending, ensuring maximum safety. Lightweight aluminium alloy does not disrupt motorcycle balance.	Lightweight frame does not burden the motorcycle, ensuring stable and comfortable riding experience.
Supporting Legs	*High Carbon Steel*	High mechanical strength and resistance to high pressure. Suitable for stabilizing the frame. Resistant to extreme weather, scratches, and corrosion.	Strong support prevents the backrest from shifting or falling. Anti-slip design on the legs enhances stability.	Sturdy supporting legs ensure the backrest remains stable, giving users a sense of safety and comfort.
Paint Coating	*Powder Coating*	Provides an attractive and recognizable aesthetic appearance.	Protects the frame from corrosion, maintaining structural integrity over a long period.	Smooth and aesthetically pleasing surface enhances visual comfort and boosts user confidence.

3.3.3. Product Installation Procedure

One aspect of ease that needs to be considered in this design is a simple and quick installation procedure. The installation of the motorcycle backrest should be easy for online motorcycle taxi drivers, whether done manually or using a quick-locking system. With an efficient installation system, users can easily install or remove the backrest as needed without requiring additional tools.

- Preparation of Tools and Components
  - Ensure all motorcycle backrest components are complete, including the main frame, cushion, and supporting legs.
  - Prepare tools such as wrenches, screwdrivers, and appropriate bolts.
- Identify Installation Location
  - Determine the installation location on the motorcycle, usually at the rear grab bar or passenger seat area.
- Install the Main Frame
  - Place the main frame in the predetermined installation position.
  - Align the mounting holes on the frame with the bolt holes on the motorcycle (grab bar or rear motorcycle frame).
- Tighten the Bolts
  - Insert bolts into the mounting holes and tighten them using a wrench or screwdriver.
  - Ensure all bolts are securely fastened to prevent shifting while the motorcycle is moving.
- Attach the Cushion
  - Install the cushion onto the main frame in the designated position.

   - Use additional locks (if available) to ensure the cushion does not shift easily.
- Check Stability
   - After all components are installed, gently shake the backrest to check its stability.
   - Ensure all parts are properly installed and nothing is loose.
- Trial Test
   - Conduct a trial by sitting on the back of the motorcycle and leaning on the backrest.
   - Check the comfort and safety of the backrest while the motorcycle is stationary.

3.3.4. Product Features

In addition to comfort and safety, the motorcycle backrest is equipped with additional features to enhance user experience. Features such as adjustment mechanisms, additional grips, and cushions that can be repositioned to suit the user's head position provide added value to the product. These features allow users to experience maximum comfort during the journey, as well as improve flexibility of use according to personal preferences. The features of the passenger backrest product are presented in Table 17.

Table 17 Passenger Backrest Product Features

Feature	Description	Benefit
Adjustment Mechanism	Height adjustment for the headrest vertically Cushion can be moved up/down or sideways.	Ensures comfort for users of various heights and adjusts the headrest to an ideal position.
Lightweight and Portable Design	Material (*Aluminium alloy)* Modular design (separable components).	Facilitates easy installation, dismantling, and storage of the backrest without difficulty.
Quick Lock System	Fast locking system using snap-lock or clip-lock.	Allows quick and easy installation and dismantling without the need for additional tools.
Easy-to-Clean Cushion	Cushions with water-resistant layers that can be easily removed for cleaning.	Simplifies maintenance and cleaning, ensuring product cleanliness over a long period.
Universal Design	Frame adjustment to fit various motorcycle types (125 cc automatic). Backrest angle adjustment.	Ensures the product can be used on various motorcycle types and provides a comfortable sitting position.

4. Conclusion

Based on the conducted research, it can be concluded that the TRIZ method was applied in designing an ergonomic backrest for female passengers using online motorcycle taxi services, aiming to address discomfort due to direct physical contact with the driver. This design considers anthropometric data of Indonesian women, resulting in key dimensions such as a backrest height of 64.95 cm, shoulder area width of 41.06 cm, and head cushion width of 20 cm, with an allowance of 2–5 cm for height and 2–4 cm for width. The materials used include aluminum alloy for the frame, polyurethane foam with synthetic leather coating for the cushion, and high-carbon steel for the supporting legs, equipped with height adjustment features, a quick-lock mechanism, and anti-slip layers.

However, this study has limitations as it does not consider cost aspects and only tests the prototype under limited conditions. For future research, it is recommended to include cost analysis, broader field testing, the development of additional features such as folding systems or automatic adjustments, and involving a more diverse user group with material durability studies to ensure the design is economically viable, inclusive, and durable.

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